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Predicting Success in Certain Aircraft Maintenance Specialties by Means of Manipulative Tests

By Edwin A. Fleishman

AIR FORCE PERSONNEL & TRAINING RESEARCH CENTER
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PREDICTING SUCCESS IN CERTAIN AIRCRAFT MAINTENANCE SPECIALTIES BY MEANS OF MANIPULATIVE TESTS

By Edwin A. Fleishman

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IMPLICATIONS

Apparatus tests of motor skills have proved their value in predicting success for certain aircrew jobs. Such tests have been an integral part of the Aircrew Classification Battery since early in World War II. On the other hand, there has never been any systematic attempt to evaluate the utility of certain manipulative tests for predicting success in any of the airman technical specialties. The Airman Classification Battery has always been confined to printed tests. Yet, it would at least seem possible that some of the airman jobs involve components of motor skill.

This report describes an exploratory investigation into this problem. It represents the first in a series of studies concerned with the utility of certain simplified apparatus tests and printed manipulative tests as possible additions to the printed Airman Classification Battery.

A battery of 16 experimental tests (yielding 25 scores) was administered to over 900 students entering either the Engine Mechanic, Hydraulic Mechanic, or Aircraft Electrician Course at Chanute Air Force Base. All of the tests had been carefully pretested on previous samples of basic airmen and possessed adequate reliabilities, were simple in construction, easily administered and scored, and provided a minimum of maintenance. The battery included measures of (a) finger dexterity, (b) manual dexterity, (c) aiming, (d) arm-hand steadiness, (e) wrist-finger speed, (f) rate of arm movement, and (g) response orientation. The tests were validated against final school grade later achieved by these students.

The primary results indicated that a number of the manipulative tests achieved significant validities, but many were of rather low magnitude. However, combinations of certain tests yielded relatively high multiple correlations with final school grade. For example, a combination of the most valid manipulative tests yielded a multiple $\underline{R}$ of .563 with success in Aircraft Electrician School. A somewhat different combination of these tests proved most valid for the Hydraulic Mechanic sample and yielded a multiple $\underline{R}$ of .449 for this school. A multiple $\underline{R}$ of only .331 was achieved for the Engine Mechanics.

A further analysis involved an evaluation of the addition made by these tests to the prediction already achieved by the Mechanical Aptitude Index actually used in selecting these students. It was found that the validity of this index was already very high, but that an increase from .747 to .775 was accomplished for the Aircraft Electrician sample by adding a few manipulative tests. An increase from .517 to .571 was achieved for the Hydraulic Mechanics by adding one printed manipulative test to the Mechanical Aptitude Index. The addition of manipulative tests to this index for the Engine Mechanic sample resulted in no essential increase in composite validity.

In general, these results show that certain combinations of manipulative tests may have considerable composite validity for predicting success in certain airman technical schools. Moreover, these tests may add to the validity of currently operational printed test procedures in the case of certain schools. It was also demonstrated that large numbers of airmen can be processed through a battery of such tests in a reasonably short time. Although these results are moderately encouraging, future recommendations regarding the utility of such tests must rest on cross validation on subsequent samples in these schools, as well as on follow-up studies with additional tests in other technical schools and with other criteria. One of the more immediate implications involves the printed manipulative tests. Two of these tests showed validities comparable to the better tests now in the Airman Classification Battery and resulted in improved predictions when added to the current tests. The fact that these printed manipulative tests can be added to the current Battery with a minimum of administrative effort suggests they be validated in a variety of technical schools for further indications of their operational utility.

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PREDICTING SUCCESS IN CERTAIN AIRCRAFT MAINTENANCE SPECIALTIES BY MEANS OF MANIPULATIVE TESTS*

Apparatus tests of motor skills have proved their value in predicting success for certain aircrew jobs. Such tests have been an integral part of the Aircrew Classification Battery since early in World War II. It has been shown that for such jobs as pilot and bombardier, a battery which includes both apparatus and printed tests achieves a prediction higher than that achieved by either kind of test alone.

On the other hand, there has never been any systematic attempt to evaluate the utility of certain manipulative tests for predicting success in any of the airman technical specialties. The Airman Classification Battery has always been confined to printed tests. Yet, it would at least seem possible that some of the airman jobs involve components of motor skill. Moreover, studies of similar kinds of jobs in industry have indicated that apparatus tests of such skills are frequently useful for selection purposes.

THE PROBLEM

The present report describes an exploratory investigation into this problem in the Air Force situation. It represents the first in a series of studies concerned with the utility of certain apparatus and printed manipulative tests as possible additions to the printed Airman Classification Battery. In the present instance, three schools in the Aircraft Maintenance area were selected for study. These were the Engine Mechanic (R-4360), Hydraulic Mechanic, and Aircraft Electrician (General) courses, all at Chanute Air Force Base. A battery of 16 experimental tests (yielding 25 scores) was administered to students entering these courses. Included among these tests were certain printed psychomotor tests designed as possible substitutes for certain of the apparatus tests. Validation of all of these tests was achieved against various school criteria.

THE EXPERIMENTAL TESTS

The experimental tests were selected for inclusion in the study on several bases.

1. A first requirement was that each test be relatively simple in construction and maintenance. This appeared necessary from the point of

* Manuscript received 16 March 1955

view of administrative feasibility. All of the tests chosen were portable and easily repaired in case of electrical or mechanical malfunction.

2. The tests were easy to administer requiring a minimum of instruction and demonstration.

3. The tests were easy to score and, where possible, scoring occurred automatically and simultaneously with actual test performance.

4. The tests were as short as possible consistent with adequate standards of reliability.

5. As far as was possible, the tests could be administered under time limit conditions. This was necessary in order to maintain a testing schedule when a series of tests must be administered within a definite period of time. Morever, conditions of group testing require some kind of time limit condition.

6. The tests had received careful pretesting and standardization on previous airmen samples.

7. The tests possessed adequate reliabilities on comparable airman samples.

8. Where several models of the same apparatus test were used, it was demonstrated previously that no significant variance was attributable to apparatus differences.

9. The factorial composition of the tests was known.

10. The tests appeared (at least superficially) to sample skills relevant to the job specialties under consideration.

The tests meeting these requirements best were selected from previous studies in this laboratory (1, 2, 3, 4). Brief descriptions of the tests selected and the scores provided by each test follow. The first nine tests were the printed psychomotor tests which were combined into a single test booklet. Certain of these were similar to those included among the MacQuarrie Tests of Mechanical Ability. The remaining 16 variables were scores provided by the apparatus tests. Actual test instructions to the examinee may be found in Appendix A.

Printed Tests

1. Medium Tapping (Figure 1): The examinee is required to make three dots in each of a series of circles 3/8 in. in diameter, working as rapidly as possible.

2. Large Tapping (Figure 2): This test is the same as 1, except circles are 1/2 in. in diameter.

3. Aiming (Figure 3): The examinee is required to make one dot in each of a series of very small circles (1/8 in. in diameter), working as fast and as accurately as possible. Score is number of dots correctly placed.

4. Pursuit Aiming I (Figure 4): The examinee is required to follow a pattern of small circles (3/16 in. in diameter) placing one dot in each circle around the pattern.

5. Pursuit Aiming II (Figure 5): This test is the same as 4, except the pattern is more difficult and the circles are smaller (1/8 in. in diameter).

6. Square Marking (Figure 6): The examinee is required to place a series of X marks precisely inside a series of small (1/8 in.) squares. Score is the number of completed squares.

7. Tracing (Figure 7): The examinee is required to trace through a series of small openings (1/16 in.) in a maze pattern. He must work as quickly as possible trying not to allow his pencil mark to touch any of the maze lines. Each touch is counted as an error. Score is the number of openings negotiated minus the number of errors.

8. Steadiness (Figure 8): The examinee must trace between a pair of narrowly separated lines (1/16 in.) which form a pattern. Score is the number of segments negotiated without touching the lines.

9. Discrimination Reaction Time--printed (Figure 9): This is a printed version of the apparatus Discrimination Reaction Time test used in the Aircrew Battery. The examinee is provided with a series of items. Each item represents a stimulus setting. There are four possible directional responses to each setting. The examinee goes from item to item as rapidly as possible checking the appropriate response. Score is the number of items completed minus the number of errors.

Apparatus Tests

10. Precision-Steadiness (time in contact) (Figure 10): The examinee is seated before a long rectangular box-like apparatus containing two openings.

Each opening is the entrance to a straight passageway which the examinee must negotiate with a long stylus. He moves the stylus forward at slightly below-shoulder height and at arm's length. He must move the stylus slowly and steadily away from his body, trying not to hit the sides of the cylindrical passage. As he reaches the end of the passage, he strikes a contact point and withdraws the stylus, again trying to avoid hitting any part of the passageway. He then negotiates the second passageway. Two complete negotiations constitute a trial. Score is the number of seconds in contact with the sides of the passage.

11. Precision-Steadiness (number of contacts): Same apparatus shown in 10 is used, except the score is the number of contacts (errors) recorded on counters.

12. Ten Target Aiming (errors) (Figure 11): The examinee is seated before a panel containing ten holes arranged at equal intervals in an elliptoid pattern. Behind each hole can be seen a circular target. These targets vary in size from hole to hole. The examinee is required to strike at these targets with a stylus, moving from target to target around the pattern of targets in a clockwise direction. He makes only one strike at a time in each hole as he moves around the pattern. He is instructed that both speed and accuracy count and that he must try to hit as many targets as possible, moving as quickly as possible from target to target. Score is the number of errors which are recorded each time the subject strikes the outside of a hole or inside around the target area.

13. Ten Target Aiming (corrects): Same apparatus shown in 12 is used, except correct counts are scored each time the examinee hits precisely within the target area in each hole.

14. Ten Target Aiming (corrects/errors): This is a ratio of the scores provided by variables 12 and 13.

15. Hand-Precision Aiming (errors) (Figure 12): The examinee is seated before a small panel consisting of two parallel metal plates. The plates are tilted toward the subject from the horizontal position. The upper plate contains 25 holes 3/8 inch in diameter in five rows of five holes each. All holes are equidistant from each other (from center to center). The subject has a small stylus with which he must punch through the holes striking the lower plate. He moves from hole to hole across one row and then across the next as rapidly as possible. He is instructed to aim accurately with each punch but to work as rapidly as possible. Score is the number of error counts recorded. An error count occurs every time the examinee strikes the upper plate.

16. Hand-Precision Aiming (corrects): Same apparatus shown in 15 is used, except score is the number of correct responses. A correct count occurs every time the examinee strikes through to the lower plate.

17. Hand-Precision Aiming (corrects/errors): This is a ratio of scores provided by variables 15 and 16.

18. Minnesota Rate of Manipulation--placing (Figure 13): The examinee is required to place 60 cylindrical blocks in the proper holes as rapidly as possible. Score is the number of blocks placed.

19. Minnesota Rate of Manipulation--turning: Same apparatus shown in 18 is used. The examinee is required to remove the blocks from the holes with one hand, turn them over with the other hand, and replace them in the same holes, moving from block to block as rapidly as possible. Score is the number of blocks turned.

20. Pin Stick (Figure 14): The examinee holds a rod containing four rows of pins on each of four sides. He is required to take the thread attached to the bottom of the rod and to make one loop around each pin as rapidly as possible going from pin to pin, up and then down the stick. Score is the number of pins threaded.

21. Purdue Pegboard--right hand (Figure 15): The examinee is required to place a number of small pegs individually in a series of small holes as rapidly as possible with the right hand. Score is the number of pegs placed.

22. Purdue Pegboard--left hand: This test is the same as 21, except that the left hand is used.

23. Purdue Pegboard--both hands: The examinee is required to pick up two pins at a time, one with each hand from different trays and place them simultaneously in two different holes. Score is the number of pegs placed.

24. Purdue Pegboard--assembly: The examinee is required to make as many completed peg-washer-collar-washer assemblies as possible in the time allowed. Score is the number of assembly components completed.

25. O'Connor Finger Dexterity (Figure 16): The examinee is required to pick up three small pins at a time from a tray of pins with the preferred hand and place them three at a time in a small hole. He must fill a series of small holes in this manner as fast as possible. Score is the number of pins placed.

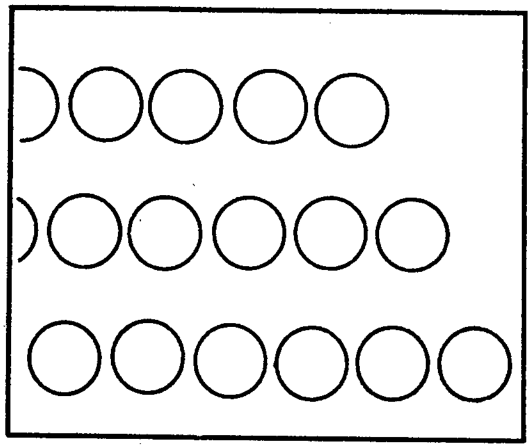

Fig. 1. Medium Tapping.

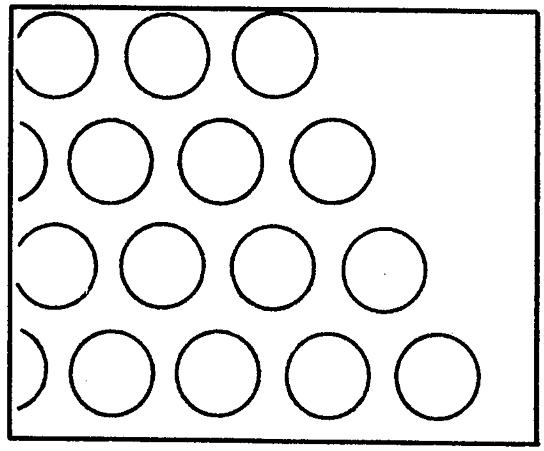

Fig. 2. Large Tapping.

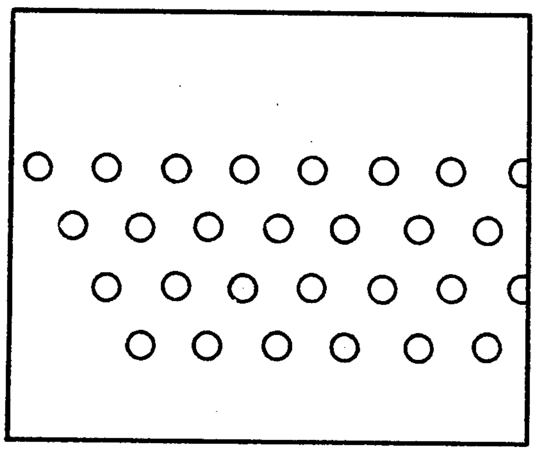

Fig. 3. Aiming.

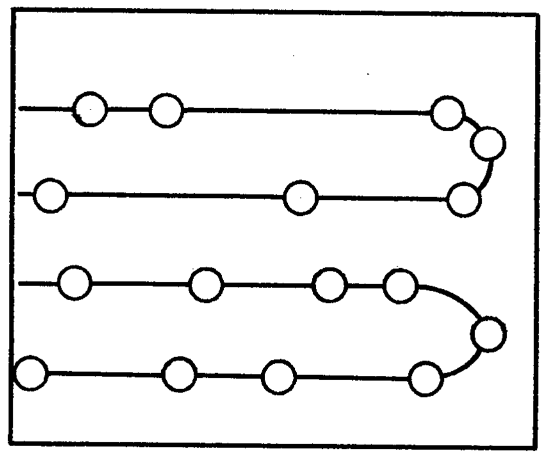

Fig. 4. Pursuit Aiming I.

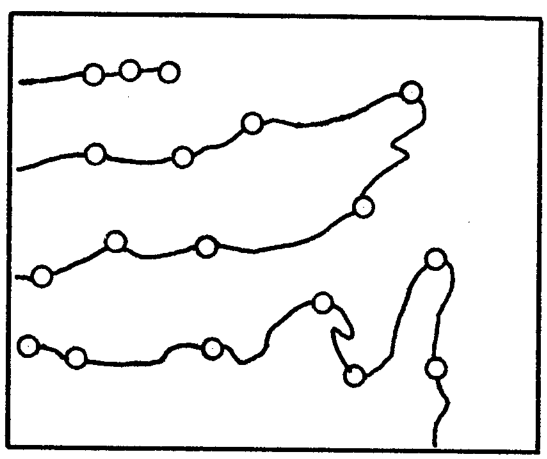

Fig. 5. Pursuit Aiming II.

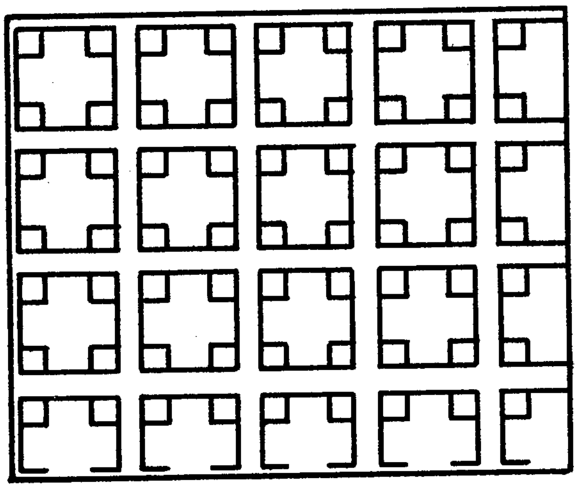

Fig. 6. Square Marking.

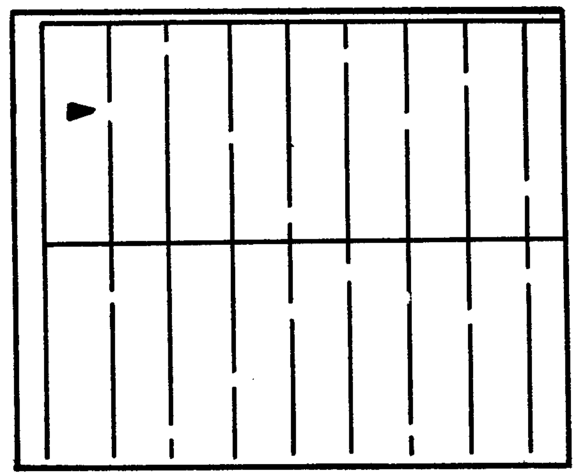

Fig. 7. Tracing.

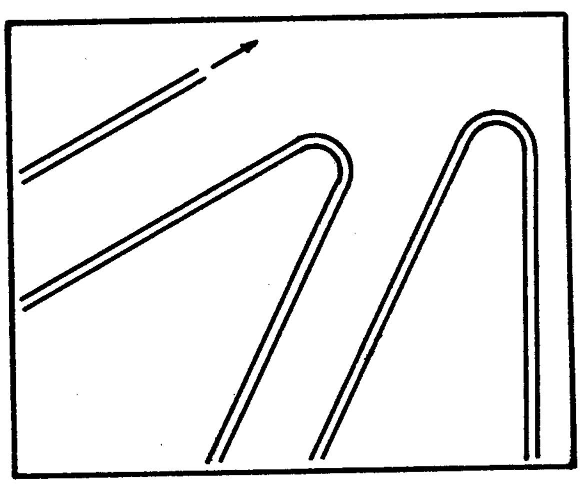

Fig. 8. Steadiness.

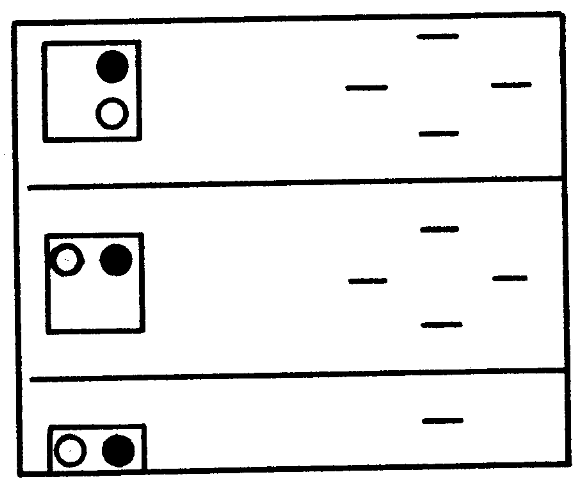

Fig. 9. Discrimination Reaction Time (paper-and-pencil).

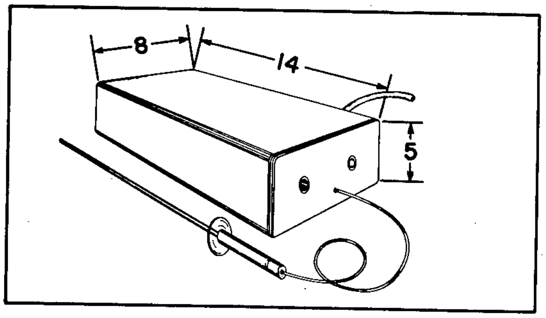

Fig. 10. Precision-Steadiness.

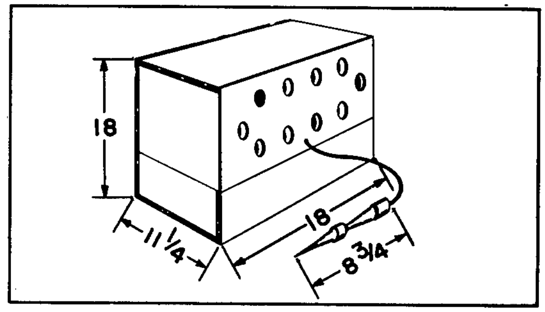

Fig. 11. Ten Target Aiming.

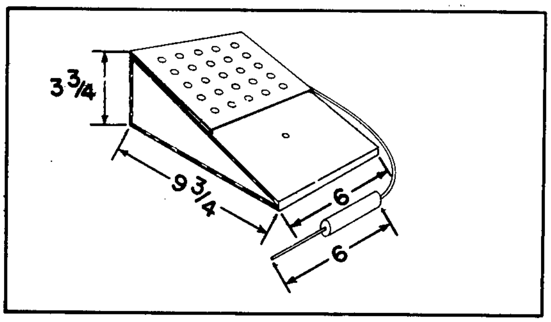

Fig. 12. Hand-Precision Aiming.

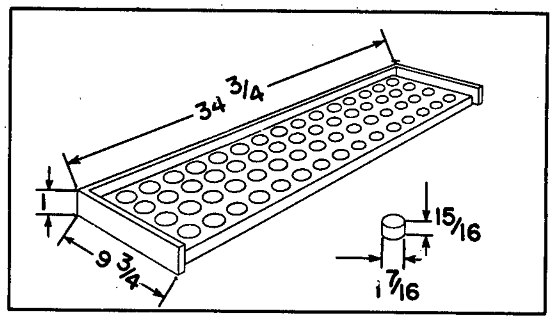

Fig. 13. Minnesota Rate of Manipulation.

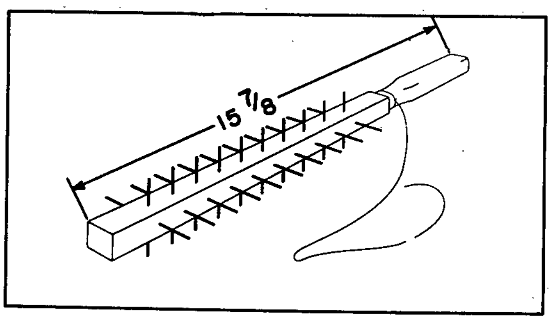

Fig. 14. Pin Stick.

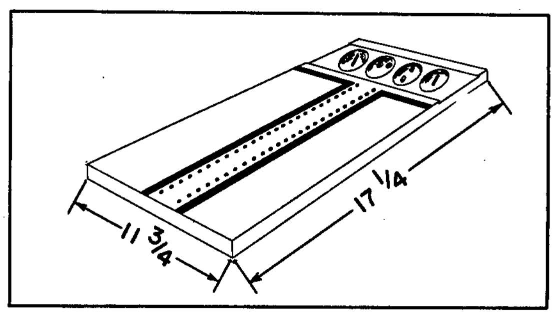

Fig. 15. Purdue Pegboard.

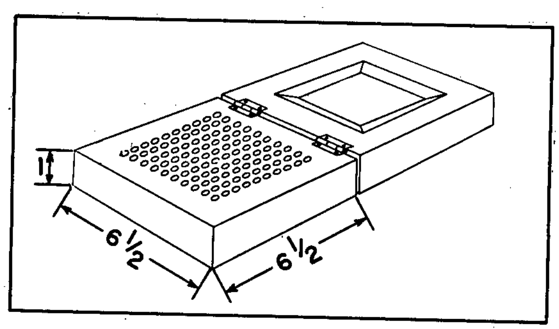

Fig. 16. O'Connor Finger Dexterity.

Test Reliabilities, Factor Content, and Administrative Conditions

Table 1 presents the administration conditions of each test in the present study, the reliabilities of each score, and the main factor measured by each test. The reliabilities of these tests are based on previous samples of at least 200 airmen each (1). The factors listed for the individual tests were isolated in previous analyses which included these tests (1, 4). It can be seen that the administration time for each test is relatively small but that the reliabilities are generally quite high. It is also evident

Table 1

Administrative Conditions, Reliability, and Factor Measured by Each Test

Test variable	Factor measured	Practice (seconds)	Number of trials	Time per trial (seconds)	Rest between trials (seconds)	Reliability[a]
Printed Tests						
Medium Tapping	Wrist-finger speed	10	1	30		.91
Large Tapping	Wrist-finger speed		1	60		.89
Aiming	Aiming (eye-hand coordination)		1	60		.89
Pursuit Aiming I	Aiming (eye-hand coordination)	15	1	30		.90
Pursuit Aiming II	Aiming (eye-hand coordination)		1	60		.89
Square Marking	Aiming (eye-hand coordination)		1	60		.88
Tracing	Aiming (eye-hand coordination)	30	1	50		.85
Steadiness	Arm-hand steadiness		2	NTL[b]		.84
Discrimination Reaction Time	Spatial relations (response orientation)		1	100		.87
Apparatus Tests						
Precision-Steadiness						
Clock	Arm-hand steadiness		6	NTL		.85
Counter	Arm-hand steadiness		6	NTL		.90
Ten Target Aiming						
Errors	Rate of arm movement		6	30	20	.94
Corrects	Manual dexterity		6	30	20	.91
Hand-Precision Aiming						
Errors			6	30	15	.99
Corrects			6	30	15	.92
Minnesota Rate of Manipulation						
Placing	Manual dexterity	25	2	45	30	.87
Turning	Manual dexterity	20	2	35	30	.79
Pin Stick	Wrist-finger speed	10	4	15	10	.77
Purdue Pegboard						
Right hand	Finger dexterity	10	2	30		.82
Left hand	Finger dexterity	10	2	30		.81
Both hands	Finger dexterity	10	2	30		.77
Assembly	Finger dexterity	10	2	60		.85
O'Connor Finger Dexterity	Finger dexterity	30	1	300		.76

[a] Reliability estimates are odd-even trial correlations corrected by the Spearman-Brown formula for the full length of the test as administered in the present study. For those tests where only one continuous trial was administered in the present study, the reliability estimates are based on separately timed half-tests.

[b] NTL indicates no time limit for these tests.

that the variety of scores in this battery covers seven different factors. These factors have been defined in previous studies as follows:

1. Wrist-Finger Speed: The speed with which either rapid rotary or bending wrist-finger movements can be made.

2. Aiming: The ability to perform quickly and precisely a series of simple, accurately directed movements requiring eye-hand coordination.

3. Arm-Hand Steadiness: The precision and steadiness with which one is able to make accurate arm-hand positioning movements of the type which minimize strength and speed.

4. Finger Dexterity: The ability to coordinate finger movements in performing fine manipulations such as grasping and releasing small objects.

5. Manual Dexterity: The ability to make skilled arm-hand manipulations such as grasping, releasing, turning, or positioning of larger objects where more of the whole hand is involved.

6. Rate of Arm Movement: The speed with which an individual can make a series of rather gross rapid arm movements.

7. Spatial Relations (Response Orientation): The ability to relate different responses to different stimuli where either stimuli or responses are arranged in spatial order. Emphasis in this spatial factor appears to be on orientation as to direction of movement.

ADMINISTRATION OF THE TESTS

The tests were administered to approximately 900 students at Chanute Air Force Base during March and April 1953 by a testing team sent from the Skill Components Research Laboratory. Each of the students either was about to begin training or was in an early stage of the course. As stated earlier, three courses were involved and these were the Engine Mechanic (R-4360), Hydraulic Mechanic, and Aircraft Electrician (general) courses. The students had originally been selected for this career field on the basis of their Mechanical Aptitude Index. They had already been through the General Aircraft and/Engine Mechanics course at Sheppard Air Force Base.

Up to 16 airmen were tested in a session. The printed test booklets were first administered to the entire group. The group then split into subgroups of four, which were assigned to the different apparatus tests. Four units of each apparatus test facilitated the flow of examinees according to a prearranged schedule. It was found that three administrators could easily test all 16 examinees on all of the tests in less than two hours. Testing was accomplished in a building convenient to the training areas. The examinees were not told that the testing was experimental, but were given the impression that their skills were being evaluated and that the scores were important to them.

Table 2

Means and Standard Deviations Achieved on Each Test by Students in the Three Technical Schools And by an Unselected Sample of Basic Airmen

	Technical school							
Test variable	Engine Mechanic (N=318)		Hydraulic Mechanic (N=305)		Aircraft Electrician (N=227)		Basic airmen[a] (N=403)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Printed Tests								
Medium Tapping	37.2	7.1	36.7	6.9	36.6	8.2	35.7	6.9
Large Tapping	74.6	13.0	75.3	13.4	73.5	14.9	70.8	13.6
Aiming	102.7	15.5	100.8	16.4	100.5	17.6	105.2	16.5
Pursuit Aiming I	63.1	9.2	62.7	10.7	62.2	11.7	64.4	10.3
Pursuit Aiming II	103.5	16.1	102.4	17.3	103.3	19.3	104.1	18.2
Square Marking	46.9	12.9	48.7	13.6	51.3	16.3	47.8	14.5
Tracing	35.8	12.1	36.2	10.8	33.4	13.2	41.3	10.2
Steadiness	11.2	7.2	10.4	7.4	11.4	7.9		
Discrimination Reaction Time--printed	61.9	28.6	65.4	24.7	60.6	32.0		
Apparatus Tests								
Precision-Steadiness--counter	289.4	116.5	274.2	111.3	262.6	111.9	265.4	120.0
Precision-Steadiness--clock (sec.)	36.6	26.4	35.4	27.6	33.0	25.8	32.4	27.6
Ten Target Aiming--errors	64.9	36.9	66.0	33.2	63.7	38.8	66.0	32.0
Ten Target Aiming--corrects	350.3	46.8	350.7	41.0	352.9	46.5	364.5	43.7
Ten Target Aiming--corrects/errors	7.7	6.6	7.1	5.0	8.8	10.7		
Hand-Precision Aiming--errors	125.2	80.1	118.9	67.4	119.4	71.8		
Hand-Precision Aiming--corrects	322.3	63.0	341.7	52.2	314.0	54.7		
Hand-Precision Aiming--corrects/errors	3.9	3.4	3.6	2.5	3.7	2.3		
Minnesota Rate of Manipulation--placing	92.9	7.0	94.3	7.1	93.4	8.3	91.0	7.7
Minnesota Rate of Manipulation--turning	90.9	9.2	92.1	9.3	91.0	10.2	87.6	9.4
Pin Stick	67.3	7.7	69.7	11.0	69.7	10.1	72.8	11.5
Purdue Pegboard--right hand	16.8	1.5	17.0	1.6	16.9	1.8	17.3	1.7
Purdue Pegboard--left hand	16.0	1.8	16.0	1.8	16.0	1.8	16.1	1.7
Purdue Pegboard--both hands	26.4	2.9	26.4	2.9	26.5	3.1	26.4	3.5
Purdue Pegboard--assembly	38.9	4.7	39.0	5.3	39.1	5.5	37.9	5.1
O'Connor Finger Dexterity	171.3	21.1	169.9	20.0	168.5	22.5	167.8	18.7

[a] The omission of data in the case of certain tests indicates that these tests had been administered to the basic airmen under a different time limit condition or scored with a different formula than employed with the student samples.

Table 3

Intercorrelations[a] Among the Experimental Tests
(N=760)

Test variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Medium Tapping		83	57	57	56	44	22	04	29	08	11	-09	36	-01	01	22	08	38	36	27	23	22	26	23	28
2. Large Tapping	83		57	57	56	46	22	03	28	07	08	-11	39	-01	-01	24	06	40	37	26	24	21	26	24	30
3. Aiming	57	57		74	75	51	20	07	19	10	15	-06	39	02	-04	30	05	42	39	31	29	29	33	25	36
4. Pursuit Aiming I	57	57	74		82	50	20	06	19	07	14	-08	39	-01	-05	27	02	43	39	31	28	27	30	26	34
5. Pursuit Aiming II	56	56	75	82		53	21	03	19	10	13	-11	39	-04	-05	28	01	41	39	29	27	26	29	27	34
6. Square Marking	44	46	51	50	53		12	03	24	10	11	-03	28	01	-04	24	01	33	32	25	22	19	27	24	32
7. Tracing	22	22	20	20	21	12		08	12	12	11	04	18	12	07	08	12	23	23	14	18	18	14	09	16
8. Steadiness	04	03	07	06	03	03	08		01	11	14	06	10	09	11	10	18	09	10	05	10	09	08	08	11
9. Discrimination Reaction Time--printed	29	28	19	19	19	24	12	01		09	08	02	10	06	05	07	09	23	23	12	09	08	13	22	15
10. Precision-Steadiness--clock	08	07	10	07	10	10	12	11	09		73	11	06	12	10	10	13	10	16	16	08	14	09	11	17
11. Precision-Steadiness--counter	11	08	15	14	13	11	11	14	08	73		15	07	15	17	08	20	14	19	22	14	14	12	17	18
12. Ten Target Aiming--errors	-09	-11	-06	-08	-11	-03	04	06	02	11	15		-51	88	46	-29	43	-01	-02	10	02	03	03	02	-06
13. Ten Target Aiming--corrects	36	39	39	39	39	28	18	10	10	06	07	-51		-33	-26	44	-15	40	38	21	26	24	23	23	28
14. Ten Target Aiming--correct/errors	-01	-01	02	-01	-04	01	12	09	06	12	15	88	-33		43	-22	42	10	06	14	07	10	06	08	01
15. Hand-Precision Aiming--errors	01	-01	-04	-05	-05	-04	07	11	05	10	17	46	-26	43		-63	90	04	04	09	01	-01	02	-02	-05
16. Hand-Precision Aiming--corrects	22	24	30	27	28	24	08	10	07	10	08	-29	44	-22	-63		-41	21	24	10	20	23	15	19	22
17. Hand-Precision Aiming--correct/errors	08	06	05	02	01	01	12	18	09	13	20	43	-15	42	90	-41		11	14	15	08	06	10	06	04
18. Minnesota Rate of Manipulation--placing	38	40	42	43	41	33	23	09	23	10	14	-01	40	10	04	21	11		60	37	47	35	44	44	43
19. Minnesota Rate of Manipulation--turning	36	37	39	39	39	32	23	10	23	16	19	-02	38	06	04	24	14	60		37	37	38	45	43	41
20. Pin Stick	27	26	31	31	29	25	14	05	12	16	22	10	21	14	09	10	15	37	37		31	26	28	30	30
21. Purdue Pegboard--right hand	23	24	29	28	27	22	18	10	09	08	14	02	26	07	01	20	08	47	37	31		42	49	42	47
22. Purdue Pegboard--left hand	22	21	29	27	26	19	18	09	08	14	14	03	24	10	-01	23	06	35	38	26	42		50	41	38
23. Purdue Pegboard--both hands	26	26	33	30	29	27	14	08	13	09	12	03	23	06	02	15	10	44	45	28	49	50		49	45
24. Purdue Pegboard--assembly	23	24	25	26	27	24	09	08	22	11	17	02	23	08	-02	19	06	44	43	30	42	41	49		49
25. O'Connor Finger Dexterity	28	30	36	34	34	32	16	11	15	17	18	-06	28	01	-05	22	04	43	41	30	47	38	45	49	

[a] For presentation, coefficients have been rounded to two places and decimals omitted.

RESULTS

Distribution Statistics

Table 2 presents the means and standard deviations of the scores made by airmen in each of the three schools. Also presented are the means and standard deviations of scores made by a group of 403 basic airmen previously tested at Lackland Air Force Base.

In general, the group of students entering each of these three schools achieved roughly comparable mean scores on these tests. Moreover, with a few exceptions, these means do not differ markedly from the mean scores obtained from the previously tested sample of basic airmen.

Test Intercorrelations

Table 3 presents the intercorrelations (Pearson product-moment) among the experimental tests based on a sample of 760 students from all three schools.

Test Validities

The results of major interest are the validities of the tests for predicting final outcome in each of the three schools. The criterion used in the present instance was final school grade. At the time this study was initiated, each of the schools employed comparable grading practices of converting grades to T scores. The final grade in each course represents a composite of several phase grades involving performance as well as written test scores.[1]

It will be recalled that the present samples of trainees were subject to considerable curtailment due to previous selection on the basis of the Mechanical Aptitude Index.[2] Since we are interested in the utility of these tests for selecting students from an unrestricted population of basic airmen, appropriate statistical corrections were applied.

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[1] Although no direct estimates are available regarding the reliability of these school grades, the intercorrelations among the phase grades were found to be high, indicating considerable final school grade reliability.

[2] During the period of this study, the Mechanical Aptitude Index included the following printed tests (the weights given these tests are in parentheses): Biographical Inventory Mechanical Key (2); Dial and Table Reading (2); General Information (1); Electrical Information (2); Mechanical Principles (1); and General Mechanics (2).

Table 4

Validities of the Manipulative Tests
For Predicting Final School Grade
In Three Technical Schools

Test variable	Uncorrected validity for Aircraft Electrician School	Uncorrected validity for Hydraulic Mechanic School	Uncorrected validity for Engine Mechanic School	Corrected validity for Aircraft Electrician School	Corrected validity for Hydraulic Mechanic School	Corrected validity for Engine Mechanic School
Medium Tapping	.23	.13	.00	.26	.22	.04
Large Tapping	.28	.14	.09	.35	.22	.14
Aiming	.20	.02	-.05	.23	.05	-.03
Pursuit Aiming I	.15	.00	-.02	.19	.04	-.05
Pursuit Aiming II	.16	.02	-.01	.20	.07	-.04
Square Marking	.04	-.02	-.05	.07	.04	.02
Tracing	.07	-.03	-.07	.09	.02	.01
Steadiness	.01	.05	.03	.06	.12	.07
Discrimination Reaction Time--printed	.31	.33	.12	.42	.40	.25
Precision-Steadiness--clock	.23	.10	.08	.26	.22	.20
Precision-Steadiness--counter	.14	.12	.06	.22	.24	.18
Ten Target Aiming--errors	.12	.06	.01	.19	.07	.16
Ten Target Aiming--corrects	.04	.10	.04	.08	.14	.00
Ten Target Aiming--corrects/errors	.19	.07	.02	.27	.08	.16
Hand-Precision Aiming--errors	.06	.05	.05	.09	.09	.23
Hand-Precision Aiming--corrects	.02	.03	-.03	.03	.04	-.10
Hand-Precision Aiming--corrects/errors	.08	.08	.05	.11	.16	.23
Minnesota Rate Manipulation--placing	.09	.14	.01	.11	.23	.08
Minnesota Rate Manipulation--turning	.21	.15	.01	.28	.25	.11
Pin Stick	.14	.09	.03	.22	.18	.08
Purdue Pegboard--right hand	.04	.06	-.09	.07	.15	-.07
Purdue Pegboard--left hand	.10	-.01	-.03	.16	.13	.04
Purdue Pegboard--both hands	.10	.03	.04	.13	.15	.14
Purdue Pegboard--assembly	.23	.16	.00	.33	.22	.14
O'Connor Finger Dexterity	.15	-.01	-.03	.17	.07	.00

The validities were corrected for restriction of range for each school separately using the procedures described by Thorndike (5).[3] Table 4 presents the uncorrected and corrected validities of each test for each of the three schools.

It can be seen that a number of these experimental tests achieved validities significant beyond the .01 level of confidence although most were of rather low magnitude. More of the individual tests appeared to predict achievement better in the Aircraft Electrician School than in the other schools. No validity above .25 was obtained for the Engine Mechanic School sample.

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[3] In addition to the obtained validity coefficients, the statistics needed for these corrections are the correlations of each experimental test with the Mechanical Aptitude Index (the restricting variable), the standard deviation of this Index in the restricted sample, and the standard deviation of this Index in an unrestricted sample. The unrestricted standard deviation used was 1.96. The restricted standard deviations were found to be 1.33, 1.16, and 1.14 for the Aircraft Electrician, Hydraulic Mechanic, and Engine Mechanic samples, respectively.

Of the individual tests, the printed Discrimination Reaction Time test achieved validities of .42 and .40 for the Aircraft Electrician and Hydraulic Mechanic samples, respectively, and emerges as the most valid single test in the battery. The Large Tapping test is another printed manipulative test with a substantial validity (.35 for Aircraft Electricians). Of the apparatus tests, Purdue Pegboard--assembly achieved the highest single validity (.33 for Aircraft Electricians), although several other apparatus tests apparently predict at a lower but still significant level.

Multiple Correlation Analysis

Of perhaps greater importance than the individual test validities are the composite validities of combinations of these tests. Although the validities of the individual tests are not high, the low correlations among the tests give promise of substantially higher multiple correlations. A limited multiple correlational analysis was undertaken to throw some light on (a) the composite prediction achieved from certain combinations of manipulative tests, and (b) the increase achieved by adding manipulative tests to the current printed Mechanical Aptitude Index. These analyses also provide some basis for inferring sources of overlap among the tests as well as for assessing the unique contribution made by the individual manipulative tests.

Completely separate analyses were carried out for each school. Thus, the intercorrelations among the individual manipulative tests and the Mechanical Aptitude Index and their validities were obtained separately for each of the three school samples. For each school, the procedure was to

1. Select those tests with the highest validities.

2. Find their intercorrelations for that school sample.

3. Correct these intercorrelations and validities for the degree of range restriction found in that particular school.

4. Calculate regression weights and multiple Rs for various combinations of these tests.

Table 5 presents the intercorrelations and validities for the tests selected from the Aircraft Electrician sample as well as the weights and multiple correlations for various combinations of these tests. It can be seen that a multiple R of .563 was achieved by a combination of only eight manipulative test scores. Some of the tests are contributing very little to this, however. Indications are that approximately the same multiple $\underline{R}$ was achieved by only five tests--printed Discrimination Reaction Time; Ten Target Aiming (corrects/errors); Large Tapping; Purdue Pegboard--assembly; and Precision-Steadiness. Dropping the printed Discrimination Reaction Time test drops this composite validity to .502.

Table 5 also indicates that the validity of the Mechanical Aptitude Index, derived from the current Airman Battery, is very high (.747). Any increase in the validity of this currently operational procedure would be very difficult to achieve. It can be seen that an increase to .775 was achieved in the present sample by the addition of a few manipulative tests, notably the Large Tapping and Precision-Steadiness tests. Although this is a numerically small increase, at this high level of prediction an increase of even this magnitude may well be of consequence in improving current selection procedures. The results also indicate that the printed Discrimination Reaction Time test, although it had an individual validity of .42, did not add to the validity of the Mechanical Aptitude Index. Apparently, the spatial factors held in common by this test and the criterion are already represented in the Airman Battery tests which currently are weighted into the Mechanical Aptitude Index.

Table 6 presents a similar analysis for the Hydraulic Mechanic sample. In this technical school, the five manipulative tests selected achieved a multiple $\underline{R}$ of .449, with the major contributions made by the printed Discrimination Reaction Time, Minnesota Rate of Manipulation--Turning, and Precision-Steadiness tests. When the most valid test, printed Discrimination Reaction Time, was left out this multiple $\underline{R}$ dropped to .337.

The validity of the Mechanical Aptitude Index was .517 for the sample from this technical school. The addition of the five selected manipulative tests raised this to .571. However, a comparable increase (to .569) was achieved by the addition of the printed Discrimination Reaction Time test alone. Apparently, the Discrimination Reaction Time test samples an ability (or abilities) involved in this criterion but not tapped by the current printed battery. Addition of the other four manipulative tests without Discrimination Reaction Time resulted in a negligible increase to .527.

Table 7 summarizes the limited analysis made for the Engine Mechanic Technical School. It will be recalled that the experimental tests possessed the lowest validities for this school sample. A multiple $\underline{R}$ of .331 was achieved from the printed Discrimination Reaction Time, Precision-Steadiness and Hand-Precision Aiming scores. The validity of the currently operational Mechanical Aptitude Index is already as high as .741, however, and the addition of these manipulative tests raised this only to .752.

Table 5

Regression Weights and Multiple Rs of Various Combinations of Tests For the Aircraft Electrician School

Test variable	Correlation[a] 1	2	3	4	5	6	7	8	9	Validity	Regression weight 1	2	3	4	5	6	7
1. Discrimination Reaction Time--printed		35	25	29	11	22	21	09	44	42	28		07				10
2. Large Tapping	30		38	37	18	58	38	-05	32	35	18	25	08	10	10	12	
3. Purdue Pegboard--assembly	18	34		50	22	25	24	-10	36	33	14	15	00	00	00		
4. Minnesota Rate of Manipulation--turning	25	34	48		24	29	38	09	27	28	01	05	03	03	02		
5. Precision-Steadiness--clock	05	16	19	23		12	26	22	17	26	12	11	12	12	12	11	
6. Aiming	19	57	23	27	10		29	-03	17	23	03	03	06	06			
7. Pin Stick	16	35	21	35	24	28		14	28	22	-01	00	-07	-07			
8. Ten Target Aiming--corrects/errors	02	-10	-16	05	20	-06	10		30	27	22	25	05	06		05	
9. Mechanical Aptitude Index	31	22	24	19	11	11	19	20		75			66	69	69	68	71
										Multiple R =	.563	.502	.775	.772	.767	.767	.754

Note.--Decimals have been omitted for the correlations, validities, and regression weights.

[a] Correlations below the diagonal are the obtained uncorrected coefficients.
Correlations above the diagonal have been corrected for restriction of range.

Table 6

Regression Weights and Multiple Rs of Various Combinations of Tests For the Hydraulic Mechanic School

Test variable	Correlation[a] 1	2	3	4	5	6	Validity	Regression Weight 1	2	3	4	5
1. Large Tapping		30	20	46	33	33	22	04	11	-01	03	
2. Discrimination Reaction Time--printed	24		25	20	30	34	40	32		24		26
3. Precision-Steadiness--clock	13	17		27	17	44	24	11	16	-02	-00	
4. Minnesota Rate of Manipulation--turning	42	13	18		46	40	25	12	12	02	01	
5. Purdue Pegboard--assembly	30	26	12	44		22	22	03	09	05	10	
6. Mechanical Aptitude Index	20	20	26	24	13		52			42	48	43
							Multiple R =	.449	.337	.571	.527	.569

Note.--Decimals have been omitted for the correlations, validities, and regression weights.

[a] Correlations below the diagonal are the obtained uncorrected coefficients.
Correlations above the diagonal have been corrected for restriction of range.

Table 7

Regression Weights and Multiple Rs of Various Combinations of Tests For the Engine Mechanic School

Test variable	Correlation[a] 1	2	3	4	5	Validity	Regression Weight 1	2	3
1. Discrimination Reaction Time--printed		16	23	27	34	25		19	02
2. Precision-Steadiness--clock	09		24	25	32	20	15	13	-02
3. Hand-Precision Aiming--errors	15	17		92	44	23	14	14	-09
4. Hand-Precision Aiming--corrects/errors	19	17	90		45	23	06	02	-04
5. Mechanical Aptitude Index	20	19	26	27		74			80
						Multiple R =	.277	.331	.752

Note.--Decimals have been omitted for the correlations, validities, and regression weights.

[a] Correlations below the diagonal are the obtained uncorrected coefficients.
Correlations above the diagonal have been corrected for restriction of range.

CONCLUSIONS

This report has described a preliminary study designed to evaluate the utility of certain apparatus and printed manipulative tests for predicting success in certain airman technical specialties. In the present instance, three schools in the Aircraft Maintenance area were selected for study. These were the Engine Mechanic, Hydraulic Mechanic, and Aircraft Electrician courses, all at Chanute Air Force Base. After careful pretesting, the experimental battery was administered to over 900 airmen entering these courses. The tests evaluated included measures of (a) finger dexterity, (b) manual dexterity, (c) arm-hand steadiness, (d) eye-hand coordination, (e) wrist-finger speed, (f) speed of gross arm movement, and (g) spatial relations (response orientation). The Mechanical Aptitude Index, based on printed tests, was also included in the analysis. The criterion of success used was final school grade achieved by students in each of the three technical schools.

The primary results indicate:

1. A number of the experimental manipulative tests achieved validities significant beyond the .01 level of confidence, although many were of rather low magnitude.

2. More of the individual tests achieved higher validities for the Aircraft Electrician School than for the other schools.

3. Of all the experimental tests, the highest individual validities were achieved by the printed Discrimination Reaction Time test (.42 and .40 for the Aircraft Electrician and Hydraulic Mechanic samples, respectively).

4. A combination of the most valid experimental tests yielded a multiple $\underline{R}$ of .563 with success in the Aircraft Electrician School. Principal contributions to this prediction were made by tests of arm-hand steadiness, finger dexterity, wrist-finger speed, and rate of gross arm movement.

5. A somewhat different combination of tests proved most valid for the Hydraulic Mechanic sample and yielded a multipe $\underline{R}$ of .449 for this school. Principal contributions here were tests of response orientation, finger dexterity, and manual dexterity.

6. The four most valid tests for the Engine Mechanic School yielded a multiple $\underline{R}$ of only .331.

7. The Mechanical Aptitude Index (Mech AI), which was actually used in selecting students for these schools, proved to have extremely high validities for the Aircraft Electrician School (.747) and the Engine Mechanic School (.741). The validity of this Index for the Hydraulic Mechanic School was .517.

8. Addition of a few manipulative tests, notably the Large Tapping (printed) and Precision-Steadiness tests, raised the validity of the Mech AI from .747 to .775 for the present Aircraft Electrician sample.

9. The validity of this Mech AI for the Hydraulic Mechanic sample was raised from .517 to .571, with practically all of this increase contributed by the Printed Discrimination Reaction Time test.

10. The addition of manipulative tests to the Mech AI for the Engine Mechanic sample resulted in no essential increase in composite validity.

At this point, it should be stressed that cross validation of these results has not yet been achieved and generalizations beyond the present samples must await confirmation from subsequent data. In general, however, these results show that certain combinations of manipulative tests may have considerable composite validity for predicting success in certain airman technical schools. Moreover, certain of these tests may add to the validity of currently operational printed test procedures in the case of certain schools if the present results are later confirmed.

In the present instance, the unique contribution of the manipulative tests to the validity of the Mech AI was not as great as might be expected from the composite validities of the manipulative tests alone. It is possible that this is due in small part to certain experiential factors held in common by the experimental and operational tests. For example, 60% of the weighting in the Mech AI involves the General Mechanics tests, the Electrical Information test and the Biographical Inventory, which are dependent almost exclusively on the background "mechanical" experience of the examinee. It is possible that this experience also contributes somewhat to facility in manipulative tests (e.g., assembly) and, hence, may account for the drop in the regression weights of certain tests when they are added to the Mech AI.

A major factor limiting the apparent utility of these experimental tests is the extremely high validities of the currently operational Mech AI derived from the Airman Classification Battery. It is very difficult to achieve any increase in a validity already over .70. Furthermore, even the increases demonstrated may be expected to shrink somewhat in subsequent samples from the same schools.[4] Thus far, there has been no opportunity for cross validation of these tests on other comparable samples. The tests should also be tried out on samples in other technical specialties, expecially those in which the validities of current aptitude indexes are not as high as those in the present study.

The criterion used in the present study was final school grade. Although this grade represents a composite of performance test scores as well as written test scores, it is likely that it is most heavily weighted with academic kinds of proficiency. The high validities of the Airman Battery printed tests present some evidence of this. It would seem likely that the validities of the manipulative tests might be higher for predicting a criterion based upon on-the-job proficiency measures. Future efforts should be directed at evaluating such tests against such criteria as contrasted with criteria involving school grades.

The present study also indicates that one combination of manipulative tests may be valid for one job specialty (e. g., aircraft electrician), but a different combination may be more valid for another specialty (e. g., hydraulic mechanics) within the same general career field. This suggests that such tests may provide assistance in sectioning airmen for training within a career field. If it is not found feasible to add such tests to the complete Airman Battery, they may still prove useful as additional classifying devices after the airmen have finished a basic career field course and before they are assigned to further specialization. The weighting of such tests in certain aptitude indexes also may reduce the degree of overlap between the different aptitude indexes now derived from the operational battery. The inclusion of such tests may also increase the stability of the various indexes in which they are included.

The above possibilities include a great deal of speculation based on the limited results of the present exploratory study. Our results are moderately encouraging, but recommendations regarding the utility of

[4] On the other hand, it should be kept in mind that the increases obtained by adding these manipulative tests to the Mech AI, which is a composite derived from several tests, simply gives an estimate of how much increase in validity was obtained in the present sample when these tests were added without changing the internal weighting of the Mech AI. As such, this procedure yields a kind of minimum estimate of the increase in composite validity that could be obtained in the present sample. A more precise estimate of how much such tests actually did would involve a more complete correlational analysis involving the individual airman battery tests.

manipulative tests must rest on cross validation on subsequent samples in these schools, as well as on follow-up studies with additional tests in other technical schools and with other criteria. Moreover, final recommendations must weigh the administrative difficulties of the manipulative tests against the unique contribution of these tests in the classification program. However, the results of the present study do indicate that high reliabilities can be obtained by very brief testing periods and that these tests can be administered in a group session. Many of the more valid tests can be administered in less than three minutes. Moreover, maintenance problems with these tests are at a minimum. It appears that with proper scheduling large numbers of airmen could be processed through a small battery of such tests in a reasonably short time.

Perhaps the clearest implications of the present limited study involve the printed manipulative tests. For example, the printed Discrimination Reaction Time test and Large Tapping test (requiring a combined total of less than five minutes to administer) were found to involve abilities not now tapped by the Airman Classification Battery tests. Moreover, for two of the schools one or both of these tests showed validities comparable to the best tests now in the Battery. The fact that these printed manipulative tests can be added to the current battery with a minimum of administrative effort suggests they be immediately cross-validated in a variety of technical schools for further indications of their operational utility.

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APPENDIX

INSTRUCTIONS TO THE EXAMINEES FOR THE APPARATUS TESTS

Precision-Steadiness
(seated)

This is a test of your steadiness. Your task is to move this stylus slowly and steadily through this opening to the other end of the passageway. You are to do this without touching the sides of the passageway with the stylus. (Demonstrate.) When the end of your stylus makes contact with the plate at the other end of the passageway, withdraw it slowly, again being careful not to touch the sides. Every time your stylus touches the sides an error will automatically be counted as well as the time you are touching the sides while you are moving the stylus.

It is important that you move slowly so as not to touch the sides, for you will be penalized for sliding the stylus in or out.

When you have completed moving the stylus in and out of opening Number One, go on to opening Number Two, and repeat the procedure. After this, rest until told to go ahead again.

Remember, move slowly and steadily.

Ten Target Aiming
(seated)

This is a test to see how fast and accurately you can strike a series of targets. You will use this stylus with your preferred hand. When I tell you to start, your task will be to strike at these targets in the holes you see before you. You will notice that these targets vary in size. You should try to hit in the center of each target. You must move from one target to the next around the panel as quickly as you can, making only one thrust at each target. (Demonstrate grip and procedure and where to start.)

You will be scored on the number of targets you hit accurately. You will also be scored for the number of misses. These will be recorded every time you hit outside the target or on this outside plate. When I say "Ready," pick up your stylus in the correct position. When I say "Go," start at this target and work as quickly and accurately as you can until told to stop. You do not have to hit the target hard to obtain a count.

Any questions?

Ready? Go!

Hand-Precision Aiming

(seated)

This is a test to see how well you can coordinate your hand movements with your eyes when you have to work quickly. Your task will be to use the small stylus to punch through the holes in the plate in front of you. You must work as quickly as you can, going from hole to hole, trying not to touch the upper plate going in or out of each hole. Errors will be counted every time you touch the plate. Work across each row from left to right. When you have finished all the holes start over from the top again until told to stop. (Demonstrate.) Remember to work as quickly as you can, trying to punch in the center of the holes. Make only one punch in each hole and then go on to the next rapidly. Your score will be based on both speed and accuracy.

Pick up the stylus with your preferred hand.

Hold the stylus over the upper left-hand hole.

Ready? Begin!

Minnesota Rate of Manipulation--Placing

(standing)

This is a test of your ability to manipulate your hands. First, slide the board filled with blocks so that the bottom edge of the board touches the guide line on the table.

(Pause; give any help needed.)

Next, lift the board off the blocks, being careful to leave them in position. Place the empty board in the clear space so that the top edge touches the guide line, and so that the holes line up with the blocks. This is the starting position for the test.

The object is to see how fast you can put the blocks back into the holes with one hand. Use whichever hand you prefer. You do it like this.

(Demonstrate slowly with increasing tempo as you speak.)

Begin on your right: put the bottom block in the top hole, the next block in the next hole, and (rapidly) so on right down the board.

(Remove the four blocks from the board and replace them in position on the table while speaking.)

You may hold down the board with your other hand if you wish. Remember, you pick them up in this order (tap the holes in the board in 1-2-3-4 order downward to the examinee). Before you finish be sure that every block is all the way down.

Your final score will be the number of blocks you can place in the time allowed. When you finish one trial, wait for the signal before starting the next trial. Now put your hand on the bottom block on your right. Ready? Go!

(Note time. Give any help needed on the 25-second practice trial. If block falls to the floor, say, "Let it go; we'll pick it up later." When the practice trial is completed, continue. . .)

That was a practice trial. Now put the board and blocks in the starting position for the next trial. (Pause.) Put your hand on the first block.

Ready? Go!

(Repeat the above procedure until all the test trials are completed, prefacing the start of each new trial with a reminder to the subjects that they are being timed. At the end of the last trial continue. . .)

That's all for this test. See that all the blocks are in the board, and that all the tops are of the same color.

Minnesota Rate of Manipulation--Turning

(standing)

This is another test of your ability to manipulate your hands. First, slide the board filled with blocks so that the top edge of the board touches the guide line on the table.

(Pause; give any help needed.)

This is the starting position for the test. The object is to see how fast you can turn the blocks over. You do it like this.

(Demonstrate slowly with increasing tempo as you speak.)

With your left hand, lift the block from the upper right-hand hole, and with your right hand put it back, bottom side up, into the same hole.

(Continue moderately across the board as you speak.)

Work to the left across the board, picking up the blocks with your left hand and putting them down with your right, bottom side up.

(Demonstrate slowly on the first block in the next row and continue moderately about halfway across while speaking.)

As you work back to the right in the next row, you pick them up with your right hand and put them down with your left.

(Start at the beginning and turn the blocks rapidly back to the original position as you speak.)

Always pick up the blocks with the hand that leads and put them down with the hand that follows. Before you finish be sure that every block is all the way down. Your score will be the number of blocks turned in the time allowed.

When you finish one trial, wait for the signal before starting the next trial. Now put your left hand on the upper right-hand block.

Ready? Go!

(Note time. Give 20-second practice period and give any help needed on practice. If a block falls to the floor, say, "Let it go; we'll pick it up later." Otherwise, it must be placed during the testing time. When the practice trial is completed, continue . . .)

That was a practice trial. Now see that the board is in the starting position for the next trial. Leave the blocks as they are. Put your hand on the first block.

Ready? Go!

(Repeat the above procedure until all the test trials are completed prefacing the start of each new trial with a reminder of the subjects being timed. At the end of the last trial continue . . .)

That's all for this test. See that all the blocks are in the board and that all the tops are the same color.

Pin Stick

(standing)

When I say "Get ready," right-handed men will pick up the rod in their left hand; left-handed men will pick up the apparatus in their right hand. When you are told to begin, you will start at the bottom pin and wrap the cord once, clockwise, around each pin working towards the top along one line until that row is completed. (Demonstrate.) When the top is reached, turn the rod 1/4 turn to the left and begin to work down in the same manner as before, and continue until told to stop.

Let's have a practice period to make sure you have it right. (Give a 10-second practice trial and correct any errors.)

Purdue Pegboard--Right Hand

(seated)

This is a test to see how quickly and accurately you can work with your hands.

Pick up one pin at a time with your right hand from the right-hand cup. (Demonstrate.) Place each pin in this right-hand row. (Demonstrate.) Start with the top hole. (Leave the pin in the hole.)

Now you insert a few pins for practice. Go ahead! (Allow 10 seconds.) Stop. (Correct any errors and answer questions.)

Take out the pins and put them back in the right-hand cup.

When I say "Begin," place as many pins as you can in the right hand row, starting with the top hole. Keep working just as rapidly as you can until I say "Stop."

Are you ready? Begin!

(30 seconds) Stop!

(Count pins and record. Have examinees return pins.)

Appendix (Cont.)

Purdue Pegboard--Left Hand

(seated)

This is a test to see how quickly and accurately you can work with your hands.

Pick up one pin at a time with your left hand from the left-hand cup. (Demonstrate.) Place each pin in this left-hand row. (Demonstrate.) Start with the top hole. (Leave the pin in the hole.)

Now you insert a few pins for practice. Go ahead! (Allow 10 seconds.) Stop. (Correct any errors and answer questions.)

Take out the pins and put them back in the left-hand cup.

When I say "Begin," place as many pins as you can in the left-hand row, starting with the top hole. Keep working just as rapidly as you can until I say "Stop."

Are you ready? Begin!

(30 seconds) Stop!

(Count pins and record. Have examinees return pins.)

Purdue Pegboard--Both Hands

(seated)

In this part of the test you will use both hands at the same time. Pick up a pin from the right-hand cup with your right hand and at the same time pick up a pin from the left-hand cup with your left hand and place the pins down the rows. Begin with the top hole of both rows. (Demonstrate.)

Now insert a few pins with both hands for practice. Go ahead! (Allow 10-seconds.)

Stop. Take out the pins and put them back in the proper cup.

When I say "Begin," place as many pins as you can with both hands, starting with the top hole of both rows. Keep working just as rapidly as you can until I say "Stop."

Are you ready? Begin!

(Allow 30 seconds.) Stop!

(Count the total number of pairs inserted and record. Subject returns pins to cups.)

Purdue Pegboard--Assembly
(seated)

(Demonstrate while saying:)

This time pick up one pin from the right-hand cup with your right hand and while placing it in the top hole in the right-hand row, pick up a washer with your left hand. As soon as the pin has been placed, drop the washer over the pin. While the washer is being placed over the pin with the left hand, pick up a collar with the right hand. While the collar is being dropped over the pin, pick up another washer with the left hand and drop it over the collar. This completes the first assembly consisting of a pin, washer, collar, and a washer.

As the final washer is being placed with the left hand, start the second assembly immediately. (Repeat above.)

Now make a few assemblies for practice. (It is important that both hands operate at all times. If he fails in practice, tell him.)

Stop. Now return to cups.

When I say "Begin," make as many assemblies as you can, beginning with the top right-hand hole. Keep working just as rapidly as you can until I say "Stop."

Are you ready? Begin!

(Allow 60 seconds.) Stop!

Appendix (Cont.)

O'Connor Finger Dexterity

(seated)

This is a test to see how fast and accurately you can work with your fingers. Your task is to fill the holes in this board with the pins from this tray.

Pick up three pins at a time and fill the holes, placing three pins in each as fast as you can. Use only one hand and put only three pins in each hole. Start in the furthest corner and work to the right. (Demonstrate.)

Fill each row completely before you start on the next row. Do not skip around. Do not stop to pick up pins you drop. Use only one hand and pick up only three pins at a time.

Ready? Go! (Allow 30-second practice trial.)

That was a practice trial. Replace the pins and get ready for the test.

Ready? Go! (Give 5-minute test period.)